Missouri Department of Natural Resources
Water Protection Program

Total Maximum Daily Load (TMDL)

for

Turkey Creek
St. Francois County, Missouri

Completed: December 23, 2004
Approved: January 13, 2005

Total Maximum Daily Loads (TMDLs)
For Turkey Creek
Pollutants: Biochemical Oxygen Demand (BOD)
Volatile Suspended Solids (VSS)

Name: Turkey Creek

Location: Near Bonne Terre in St. Francois County, Missouri

Hydrologic Unit Code (HUC): 07140104-080003

Water Body Number (WBID): 3282

Missouri Stream Class: P [1]

Beneficial Uses:
- Livestock and Wildlife Watering
- Protection of Warm Water Aquatic Life
- Protection of Human Health associated with Fish Consumption

Size of Impaired Segment: 1.5 miles

Location of Impaired Segment: From NE ¼ Section 2, T37N, R4E (downstream) to NE ¼ Section 11, T37N, R4E (upstream)

Pollutants:
- Biochemical Oxygen Demand (BOD)
- Volatile Suspended Solids (VSS)[2]

Pollutant Source: Bonne Terre Northwest Wastewater Treatment Facility

Permit Number: Missouri State Operating Permit No. MO-0100706 [3]

TMDL Priority Ranking: High

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[1] Streams that maintain permanent flow even in drought periods. See Missouri Water Quality Standards (WQS) 10 Code of State Regulations 20-7.031(1)(F). The WQS can be found at the following uniform resource locator (URL): http://www.dnr.mo.gov/wpscd/wpcp/wqstandards/wq_standard_hm.htm

[2] Any waterbody that was listed for Non-filterable Residue (NFR) in 1998, such as Turkey Creek, is now being listed for Volatile Suspended Solids (VSS). This change was made to better distinguish between organic solids coming from wastewater treatment plants (VSS) and mineral solids (soil or mineral particles) coming from soil erosion or erosion of mine waste materials or stockpiles (Non-Volatile Suspended Solids or NVSS).

[3] The state permitting system is Missouri's program for administering the National Pollution Discharge Elimination System (NPDES) program.

1. Background And Water Quality Problems

Geography:
Turkey Creek flows north past the city of Bonne Terre into Big River in St. Francois County. The creek's watershed is about 3.75 square miles or 2400 acres. Underneath the watershed are the "played out" underground lead mines of Bonne Terre.

Area History[4]:
Farmington's roots go back to 1798 when William Murphy crossed the Mississippi River into Spanish Territory looking for a place to bring his family. Native Americans familiar with the area guided him to a perfect spot next to a spring. His decision made, he obtained a Spanish Land Grant and permission to start a settlement along the St. Francois River (now spelled St. Francis). Unfortunately, Murphy died while returning to Kentucky for his wife, their children and grandchildren.

Sarah Barton Murphy and her sons decided to go ahead with her husband's plans and Murphy's Settlement was established a year or so later. Despite many hardships and difficulties, the new community thrived. Sarah Barton Murphy is also credited with organizing the first Protestant Sunday School west of the Mississippi. Descendents of the Murphy family still live in Farmington and are active in the community.

The Louisiana Purchase brought the territory into the United States. When the state of Missouri was created, David Murphy donated 52 acres for the development of a county seat for the about-to-be-formed St. Francois County. This same tract of land is currently the heart of Farmington's downtown business district.

St. Francois County was coveted for its lead production by both sides during the Civil War. It was also used as a staging area for troops out of St. Louis. Despite the heavy concentration of Union soldiers, a notorious Confederate guerilla leader, Sam Hildebrand, managed to commandeer the St. Joe Lead Mines. The guerillas held out for several weeks while manufacturing lead for General Sterling Price's invasion of Missouri. Afterwards, Price ordered the furnaces blown up so that they would not fall into Federal hands. One of Hildebrand's many local hideouts, a cave in St. Francois State Park, still bears his name.

Land Use and Soils:
The soils along Turkey Creek are of the Caneyville-Crider-Gasconade Association with a 2-35 percent slope. The creek is part of the Farmington Plain that is dissected by Big River and its tributaries. The Caneyville silt loam has a 9-14 percent slope, is moderately deep, and is strongly sloping, well drained soil found on upland side slopes. It has slow permeability and medium surface runoff. The Crider silt loam along the creek is similar to the Caneyville, only it is deep and moderately sloping (5-9 percent). Gasconade flaggy silty clay loam has a slope of 9-35 percent. It is shallow, strongly sloping to steep, somewhat excessively drained soil on uneven side slopes. The permeability is moderately slow while runoff is rapid. The bottom-land soil is the Haymond silt loam, 0-2 percent slope. This deep, nearly level soil is well drained with

[4] Farmington-City of Tradition and Progress, http://fxnet.missouri.org/econdev/lochist/htm and The Civil War, St. Francois county, Missouri, http://rosecity.net/civilwar.stfc.html

moderate permeability and slow runoff. It is prone to floods of short duration. Upstream of the wastewater treatment lagoons, the soil is Psamments, sloping. This is newly formed soil on low slopes and tailing ponds. It is formed in crushed dolomitic material from lead mining (chat).

Land use in the area is 49 percent grasslands and 42 percent forest and woodlands with at least one huge chat pile (which has been stabilized). About nine percent of the land is urban. See the Land Use Map in Appendix A.

Defining the Problem:
The Missouri Department of Natural Resources (the department) has performed visual examination and sampling of the kinds of aquatic invertebrates (like water insects and crayfish) in Turkey Creek. These results show reduced diversity of aquatic invertebrate animals downstream from the Bonne Terre Northwest Wastewater Treatment Facility (WWTF). The1998 listing for the impaired reach was based in part on six samples collected 0.2 mile, 0.5 mile and 1.4 miles downstream of the plant on July 30, 1985. Also, department personnel observed violations of narrative standards for volatile suspended solids (citing sludge deposits, floating paper and sewer odors) directly downstream and attributable to the WWTF on July 18 & 30, 1985; June 24, 1987; Sept 16, 1988 and in 1993. In 1993 the operator acknowledged that bypassing of raw sewage by a lift station located next to Turkey Creek was a chronic problem.

The reason these violations are a concern is that wastewater high in Biochemical Oxygen Demand (BOD) reduces the amount of dissolved oxygen in the stream's water. Most aquatic organisms require high levels of oxygen to survive. In addition, volatile suspended solids (VSS), also known as suspended solids, can settle onto the bottom of a stream smothering natural substrates (materials in the streambed), aquatic invertebrate animals and fish eggs.

The Bonne Terre Northwest WWTF, permit number MO-0100706, has an oxidation ditch, UV disinfection, and a sludge storage basin (the sludge is land applied). The design flow is 610,000 gallons per day (which translates to 0.9455 cubic feet per second (ft^3/sec)). It discharges to an unnamed and unclassified tributary about ¼ mile upstream of the tributary's confluence with Turkey Creek. Like all wastewater discharges in Missouri, the Bonne Terre WWTF has to meet the requirements of a discharge permit issued by the department. Their current limits for BOD are 45 milligrams per liter (mg/L) weekly average and 30 mg/L monthly average, or 45/30. The current limits for Total Suspended Solids (TSS)[5] are 45/30. The permit expires on January 13, 2005.

2. Description Of The Applicable Water Quality Standards And Numeric Water Quality Targets

Designated Uses[6]:
The designated uses of this section of Turkey Creek, WBID 3282, are:
- Livestock and Wildlife Watering
- Protection of Warm Water Aquatic Life
- Protection of Human Health associated with Fish Consumption

[5] VSS is the volatile (can be burned off) portion of TSS. The VSS standard (as a narrative of no noticeable downstream objectionable deposits) will be achieved by a daily maximum TSS permit limit.
[6] The designated uses may be found at 10 CSR 20-7.031 (1)(C) and Table H.

Use that is Impaired:
Protection of Warm Water Aquatic Life

Anti-degradation Policy:
Missouri's Water Quality Standards include the U.S. Environmental Protection Agency (EPA) "three-tiered" approach to anti-degradation, and may be found at 10 CSR 20-7.031(2).

Tier 1 – Protects existing uses and provides the absolute floor of water quality for all waters of the United States. Existing instream water uses are those uses that were attained on or after November 29, 1975, the date of EPA's first Water Quality Standards Regulation, or uses for which existing water quality is suitable unless prevented by physical problems such as substrate or flow.

Tier 2 – Protects the level of water quality necessary to support propagation of fish, shellfish, and wildlife and recreation in and on the water in waters that are currently of higher quality than required to support these uses. Before water quality in Tier 2 waters can be lowered, there must be an antidegradation review consisting of: (1) a finding that it is necessary to accommodate important economical or social development in the area where the waters are located; (2) full satisfaction of all intergovernmental coordination and public participation provisions; and (3) assurance that the highest statutory and regulatory requirements for point sources and best management practices for nonpoint sources are achieved. Furthermore, water quality may not be lowered to less than the level necessary to fully protect the "fishable/swimmable" uses and other existing uses.

Tier 3 – Protects the quality of outstanding national resources, such as waters of national and State parks and wildlife refuges and water of exceptional recreational or ecological significance. There may be no new or increased discharges to these waters and no new or increased discharges to tributaries of these waters that would result in lower water quality (with the exception of some limited activities that result in temporary and short-term changes in water quality).

Specific Criteria:

Biochemical Oxygen Demand (BOD)

Dissolved oxygen (DO) is the water quality standard that is exceeded in Turkey Creek. DO is not a pollutant and cannot be allocated in a TMDL. Biochemical Oxygen Demand (BOD) is the parameter used to determine the impact that wastewater will cause on DO levels in a receiving stream. There is no numeric criterion in the Missouri Water Quality Standards (WQS) for BOD. Since DO cannot be allocated, but **does** have a numeric criterion, DO is linked to BOD. BOD is a pollutant that is measurable and may be allocated in a TMDL.

BOD is composed of carbonaceous oxygen demand ($CBOD_5$) and nitrogenous oxygen demand (NBOD). NBOD is estimated directly from Total Kjeldahl Nitrogen (TKN), which is ammonia nitrogen (NH_3-N) plus organic nitrogen. The numeric link between DO and BOD is generated by the water quality model QUAL2E, and is supported by EPA. The QUAL2E model calculates BOD by using $CBOD_5$, organic nitrogen, and ammonia data from actual sample analyses. State water

quality standards for all Missouri streams except cold water fisheries call for daily minimum of **5 milligrams per liter (mg/L or parts per million) dissolved oxygen**[7] or the normal background level of dissolved oxygen, whichever is lower.[8]

Volatile Suspended Solids (VSS)

Several stream surveys conducted during summer low flows by the department resulted in Turkey Creek being placed on the 1998 303(d) impaired waters list for the presence of sewage sludge. There is no numeric standard for VSS. Deposits of sewage sludge (VSS) in waters of the state are interpreted as violations of the general (narrative) criteria of the Water Quality Standards. These standards may be found in 10 CSR 20-7.031(3)(A) and (C) where it states:

- "Waters shall be free from substances in sufficient amounts to cause the formation of putrescent, unsightly or harmful bottom deposits or prevent full maintenance of beneficial uses."
- "Waters shall be free from substances in sufficient amounts to cause unsightly color or turbidity, offensive odor or prevent full maintenance of beneficial uses."

Numeric Water Quality Targets:

For details on how the targets were derived, see the Wasteload Allocation, Section 5.

Biochemical Oxygen Demand (BOD)

The target value for BOD is set to maintain the state criteria plus a ten percent margin of safety for a minimum of 5.5 mg/L of dissolved oxygen throughout the stream.

Volatile Suspended Solids (VSS)

The target value for VSS was set for 5 mg/L at the junction of the effluent tributary and Turkey Creek.

Total Nitrogen and Total Phosphorus (Nutrients)

Nutrient load is an additional cause of depletion of dissolved oxygen. The target for the nutrient load from the Bonne Terre WWTF is to be equivalent to the background load, which is 2.69 pounds per day Total Nitrogen and 0.25 pounds per day Total Phosphorus.

3. Calculation of Load Capacity

Load Capacity (LC) is defined as the greatest amount of a pollutant a waterbody can assimilate without violating Missouri Water Quality Standards. This total load is then divided among a Wasteload Allocation (WLA) for point sources, a Load Allocation (LA) for nonpoint sources and a Margin of Safety (MOS). To calculate the total load (or LC), this formula is used:

(design stream flow in ft^3/sec*)(maximum allowable pollutant concentration in mg/L)(5.395*)= pounds/day*

*5.395 is the constant used to convert ft^3/sec times mg/L to pounds/day.

To find that pollutant concentration, the QUAL2E model was used. Calibration of the model was based on two 48-hour studies that the Environmental Services Program (ESP) did on Turkey Creek in July and August of 2002. In the July 23-24 sampling period, flow in Turkey Creek was very low, and the plant was functioning poorly. Sludge was observed in Turkey Creek below the confluence with the WWTF tributary. During the August 28-29 sampling period, there was higher flow in the

[7] 10 CSR 20-7.031(4)(J)
[8] 10 CSR 20-7.031(4)(A)(3)

stream, originating from the Bonne Terre Mine/Billion Gallon Lake resort in downtown Bonne Terre. The wastewater treatment plant was functioning more efficiently than in the previous survey and there was little impairment evident in Turkey Creek.

The QUAL2E model was calibrated to bring the simulation of flow, velocity, BOD, dissolved oxygen, organic nitrogen, ammonia nitrogen, nitrate and nitrite nitrogen, total phosphorus, and VSS within the range of measured data for these parameters.

4. Load Allocation (Nonpoint Source Load)

Load Allocation (LA) is the maximum allowable amount of the pollutant that can be assigned to nonpoint sources. There are no known nonpoint sources of BOD and VSS in the impaired stream segment. Thus the nonpoint source load allocation is zero pounds per day.

5. Waste Load Allocation (Point Source Loads)

The Wasteload Allocation (WLA) is the maximum allowable amount of the pollutant that can be assigned to point sources. The WLAs for BOD and VSS were derived from adjusting the plant discharge in the model to full design flow of 0.95 ft^3/sec and the instream flow to 0.1 ft^3/sec. An additional test was done with the model with the application of winter conditions.

Biochemical Oxygen Demand (BOD)

The target value for BOD was geared to maintain the state criteria plus a ten-percent margin of safety for a minimum of 5.5 mg/L of dissolved oxygen throughout the stream. The effluent tributary is unclassified, and about ¼ mile in length. No mixing zone in the main stream was considered.

Calibrating the model to observed DO concentrations resulted in a substantial increase of Sediment Oxygen Demand (SOD) in the tributary and in Turkey Creek. This is consistent with the observation of bottom deposits of sludge in the stream during the July 2002 stream survey (MDNR 2002). Compliance with water quality standards will be difficult to achieve as long as sludge is allowed to accumulate in the stream bottom.

The influence of ammonia and organic nitrogen concentration was factored in with a BOD concentration of 8 mg/L to determine the minimum concentration of dissolved oxygen that would result in the stream. This level was selected as the lowest practical limit for an oxidation ditch. Results are in Figures 1 and 2. In Figure 2, the lowest practicable limit for an oxidation ditch for NO_3-N was selected. That was 1.2 mg/L. If the SOD factor can be mitigated through reduction of sludge in the stream, then compliance is possible.

Figure 1: Minimum Dissolved Oxygen in Turkey Creek as a function of organic nitrogen concentration of WWTF effluent. BOD = 8 mg/L; NH_3-N = 1.2 mg/L.

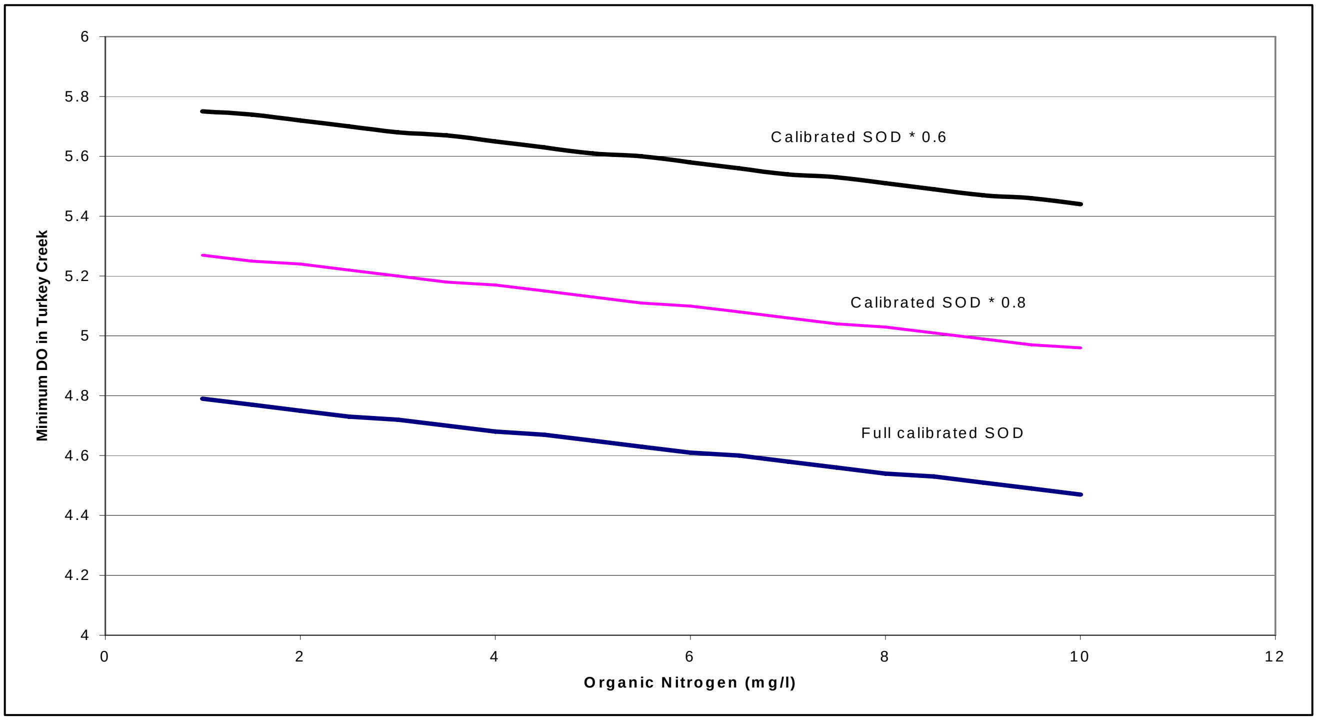
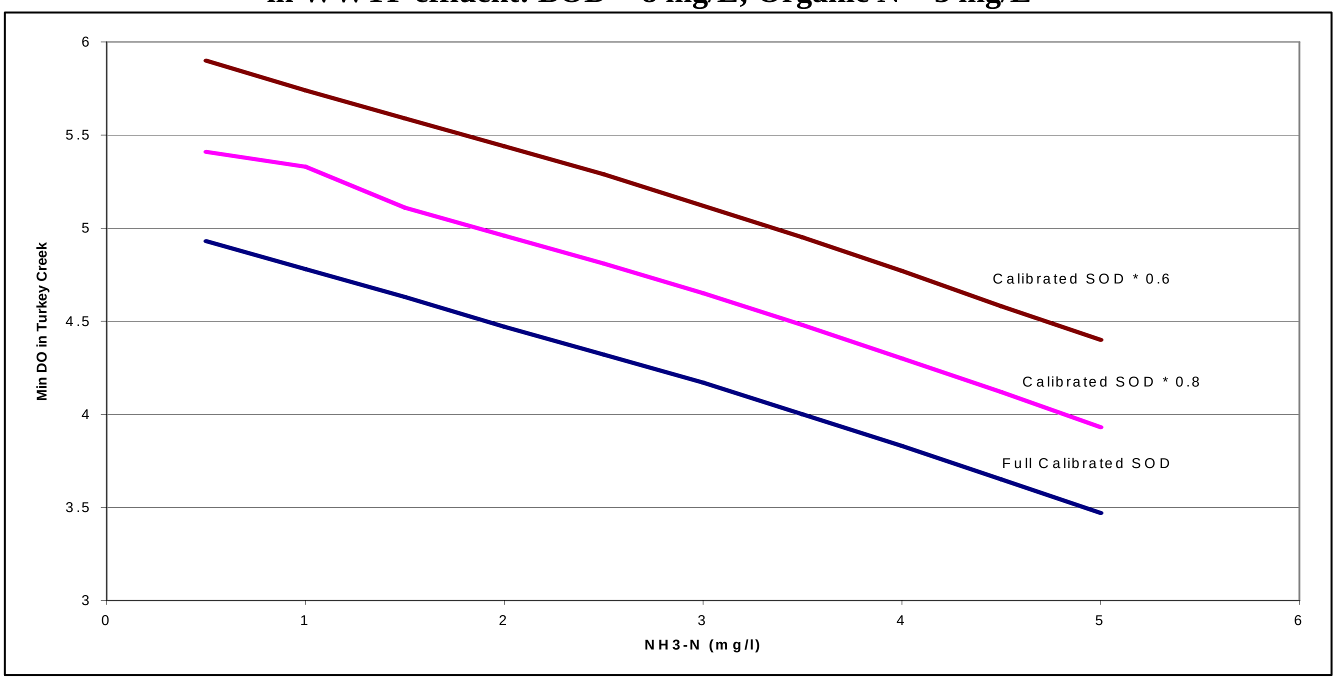


Figure 2: Minimum Dissolved Oxygen in Turkey Creek as a function of NH3-N concentration in WWTF effluent: BOD = 8 mg/L; Organic N = 3 mg/L



The WLA for BOD is calculated using this formula:

(WWTF design flow in ft^3/sec*)(BOD in mg/L)(5.395) = BOD in pounds/day*

(0.9455)(10)(5.395) = **51.0 pounds/day of BOD**

Volatile Suspended Solids (VSS)

The target value for VSS was determined by examining all the instream data and selecting the 25th percentile. For this data set, that value is 2.499 mg/L, which is the standard notation for non-detection where the lowest detectable concentration is 5 mg/L. The target value was therefore set for 5 mg/L at the junction of the effluent tributary and Turkey Creek. Using QUAL2E, the target is achieved in both warm and cold weather with a WLA concentration of 10 mg/L VSS. This comes out to the same load as for BOD:

$$(0.9455)(10)(5.395) = \mathbf{51.0\ pounds/day\ of\ VSS}$$

Total Phosphorus and Total Nitrogen (Nutrients)

Nutrient load is an additional cause of depletion of dissolved oxygen. This happens through several processes, including algae respiration and decomposition, and oxidation of ammonia and nitrite nitrogen. Samples taken from Turkey Creek indicated significant concentrations of total nitrogen and very high concentrations of total phosphorus, up to 6.4 mg/L. While there is currently no state regulation governing the levels of total nitrogen and total phosphorus in the stream, these concentrations are indicative of significant impairment.

The effects of variation of organic nitrogen and nitrite levels in the effluent on DO in the stream were tested, and the results are in Figures 3 and 4. In and of themselves, these direct chemical effects from the nutrient load do not appear highly significant in oxygen reduction. More likely, nutrient induced algae respiration and decomposition are greater factors. The July 2002 field report indicated "heavy growth of dark gray/green/black epilithic periphiton [algae growing on the rocky/gravelly stream bottom], directly below the confluence with the effluent discharge. A light growth of epilithic periphyton was present on the substrate above the confluence."

Figure 3: Dissolved Oxygen in Turkey Creek as a function of organic nitrogen in WWTF effluent. Assumptions: NH3-N = 1.2 mg/L; BOD = 8 mg/L.

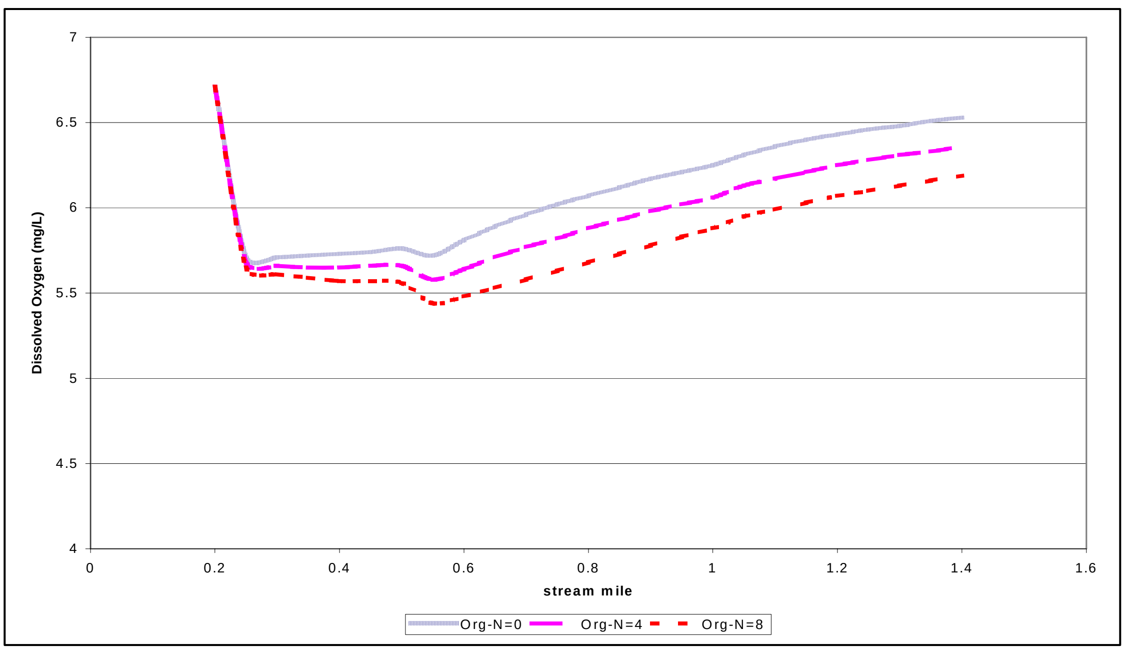
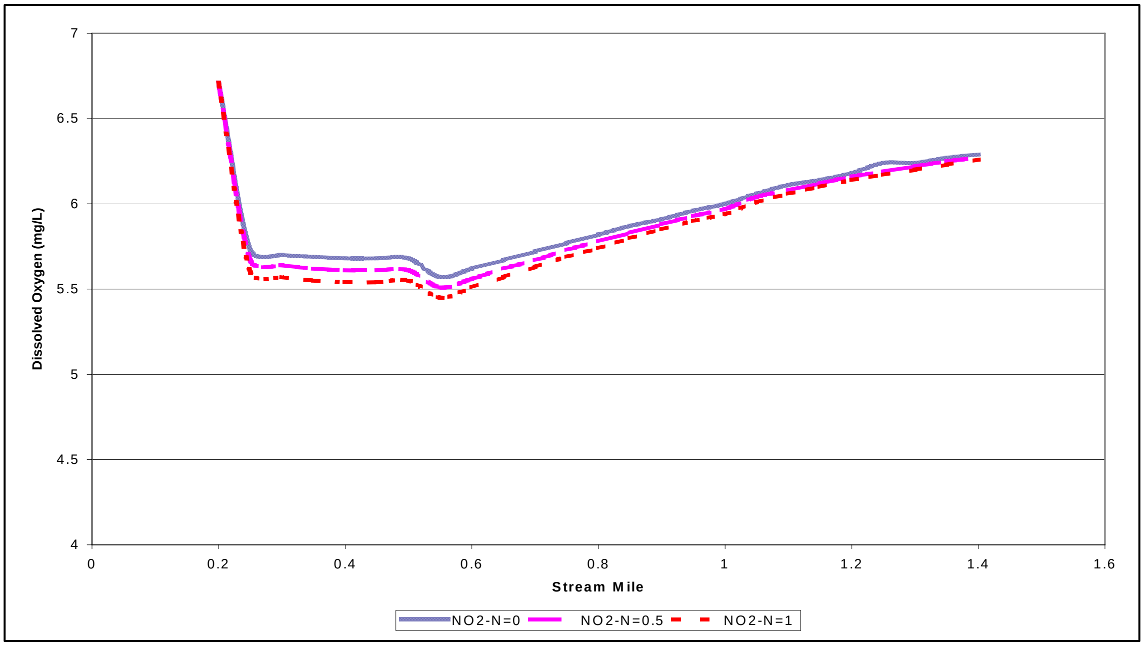
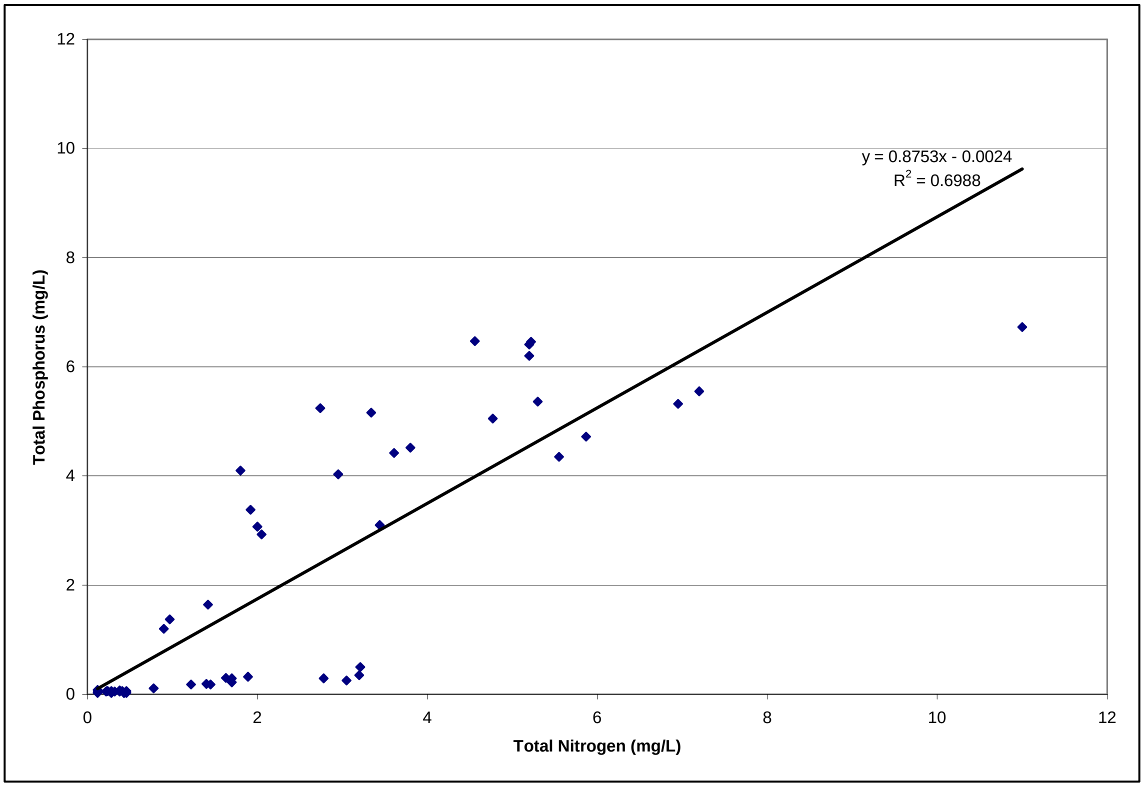


Figure 4: Dissolved Oxygen in Turkey Creek as a function of nitrite nitrogen in WWTF effluent. Assumptions: NH3-N = 1.2 mg/L; BOD = 8 mg/L.



A comparison of the total nitrogen and total phosphorus data yields very low nitrogen to phosphorus ratios, which means that nitrogen is the limiting nutrient and is therefore the one that needs to be monitored (Figure 5). To control nitrogen, the amount of ammonia (NH_3-N) reaching the stream must be reduced.

Figure 5: Total Nitrogen and Total Phosphorus in all samples taken in the Turkey Creek Wasteload Allocation Study



The background nutrient load consists of the amount, in pounds per day, of total nitrogen and total phosphorus measured upstream from the confluence with the effluent tributary plus the amount in other contributing tributaries. The target for the nutrient load from the Bonne Terre WWTF is to be equivalent to this background load.

The background nutrient load was calculated using flow in the upstream and tributary locations, the geometric mean for concentrations of total nitrogen and total phosphorus, and the conversion factor of 5.395 (which converts the units to pounds per day). Again, this takes the form of:

$$(\text{flow in ft}^3/\text{s})(\text{concentration in mg/L})5.395 = \text{lbs/day}$$

Table 1: Geometric means of stream flows and background nutrient concentrations

	Flow (ft^3/s)	Total Nitrogen (mg/L)	Total Phosphorus (mg/L)
Upstream of effluent trib	0.577	1.01	0.444
2nd trib	0.022	1.85	0.338
3rd trib	0.042	0.242	0.058

The sum of the loads for each of the three streams in Table 1 equals the background loads as follows:

Total Nitrogen Load = [(0.577*1.01)+(0.022*1.85)+(0.042*0.242)] = **3.42 lbs/day**
Total Phosphorus Load = [(0.577*0.444)+(0.022*0.338)+(0.042*0.058)] = **1.44 lbs/day**

The point source load from Bonne Terre WWTF is in Table 2.

Table 2: Geometric mean of Bonne Terre WWTF actual flow and nutrient concentrations

	Flow (ft^3/s)	Total Nitrogen (mg/L)	Total Phosphorus (mg/L)
Outfall #1	0.3617	5.31	5.49

Total Nitrogen Load =(0.3617)(5.31)(5.395) = **10.36 lbs/day**
Total Phosphorus Load = (0.3617)(5.49)(5.395) = **10.71 lbs/day**

In order to mitigate the impact of nutrients from the Bonne Terre WWTF, the above figures were used to calculate the needed nutrient reduction as follows:

Total nitrogen: (10.36 – 3.42)/10.36 * 100 = 67 percent reduction
Total phosphorus: (10.71-1.44)/10.71 * 100 = 86.6 percent reduction

Table 3 lists the WLA concentrations for the TMDL. Permit limits will be derived from the WLAs.

Table 3: WLAs for Bonne Terre WWTF

BOD (mg/L)	10
VSS (mg/L)	10
NH_3-N (mg/L) May – Oct	1.2
NH_3-N (mg/L) Nov – Apr	3

6. Margin Of Safety (MOS)

A Margin of Safety (MOS) is required in the TMDL calculation to account for uncertainties in scientific and technical understanding of water quality in natural systems. The MOS is intended to account for such uncertainties in a conservative manner. Based on EPA guidance, the MOS can be achieved through one of two approaches:

(1) Explicit - Reserve a portion of the loading capacity as a separate term in the TMDL.
(2) Implicit - Incorporate the MOS as part of the critical conditions for the waste load allocation and the load allocation calculations by making conservative assumptions in the analysis.

The target value for BOD was set to maintain the state criteria plus an explicit 10 percent MOS for a minimum of 5.5 mg/L of dissolved oxygen throughout the stream. The permit monitoring will provide assurance that the water quality standards will be achieved and therefore provides another degree of conservatism in the TMDL.

7. Seasonal Variation

Because the impairment is due to a single point source, and there are no nonpoint sources, the consideration of the critical low flow takes into account seasonality. It would be at that low flow where concern would arise as to not meeting the permit limits and thus violating Missouri Water Quality Standards. Also, the limits for ammonia are calculated differently for different seasons.

8. Monitoring Plans

The department plans for the following monitoring in Turkey Creek: a low flow study 2004 [50 percent complete], a sediment study in 2005 and special studies in 2006 and 2007. In addition, instream monitoring is already required in Bonne Terre’s permit, which states: “Monthly in-stream monitoring shall be performed at locations ¼ (one quarter) and 1 (one) mile below the outfall for ammonia and early-morning dissolved oxygen (during summer months [June through September]).” As with all of Missouri’s TMDLs, if continuing monitoring reveals that water quality standards are not being met, the TMDL will be reopened and re-evaluated accordingly. This TMDL will be incorporated into Missouri’s Water Quality Management Plan.

9. Implementation

This TMDL will be implemented through permit limits. The current Bonne Terre Northwest WWTF permit (MO-0100706) has limits for BOD of 45/30 mg/L (weekly/monthly averages) and 45/30 mg/L for TSS and is due to be renewed January 2005. New permit limits will be included. They will be calculated from the WLA based on methods in the EPA Technical Support Document.

In order to develop achievable effluent limits that would maintain a sufficiently high probability of compliance with water quality standards in Turkey Creek, the performance potential of an oxidation ditch needs to be considered. Table 4 describes general performance from a sample of 16 oxidation ditch plants (EPA, 1992).

Table 4: Percentage of time effluent concentration was less than benchmark concentrations

Benchmark Concentration (mg/L)	Suspended Solids		BOD	
	Winter	Summer	Winter	Summer
0.2	0	0	0	0
0.5	0	0	0	0
1.0	2	1	0	2
2.0	7	13	5	12
5.0	49	67	57	64
10.0	82	90	92	93
20.0	97	96	99	100

Discharge Monitoring Report data from the Bonne Terre facility indicate that, compared to the oxidation ditch systems from which data were drawn for Table 4, there is considerable room for improvement (Figures 7 & 8). Tertiary treatment, such as a filtration system, would directly reduce the total suspended (and volatile) solids, which would in turn lead to a reduction of BOD.

The oxidation ditch systems sampled in Table 4 do not have tertiary treatment. There are, however, a number of systems in the country with oxidation ditches and filtration systems that effectively reduce BOD and TSS to less than 5 mg/L. The city of Brighton, Michigan, uses such a system. From June 2002 to June 2004, the effluent had a maximum monthly average CBOD concentration of 1.4 mg/L and a maximum daily concentration of 2.4 mg/L. TSS maximum monthly average concentration was 1.7 mg/L and maximum daily concentration was 3.0 mg/L (Michigan DEQ 2004).

Figure 7: Comparison of average monthly BOD of Bonne Terre WWTF and 16 other oxidation ditch systems.

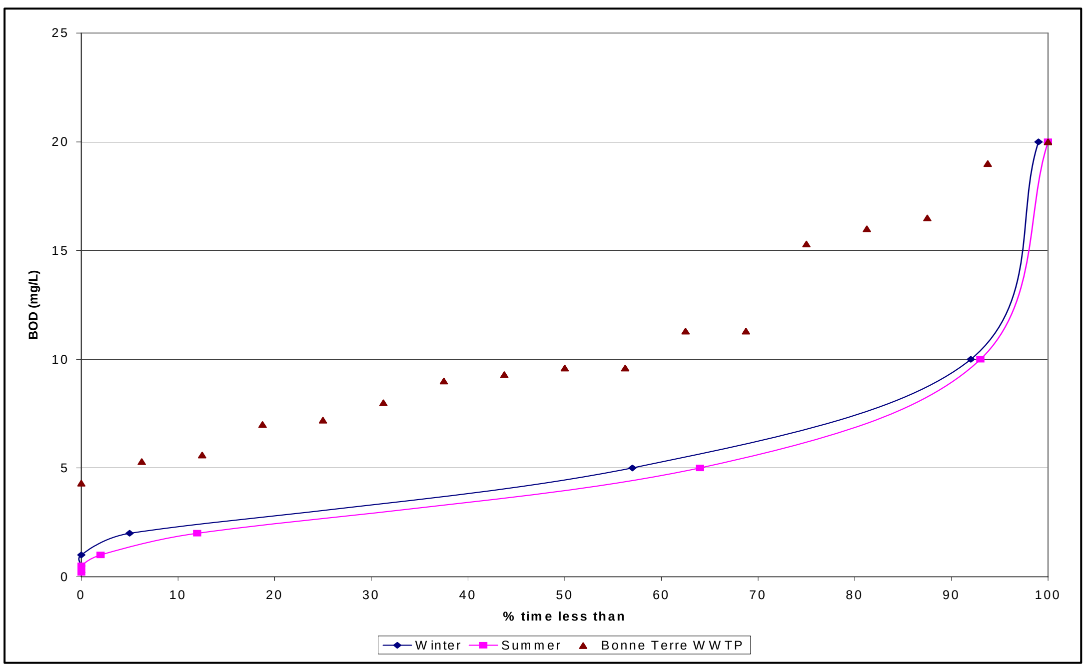
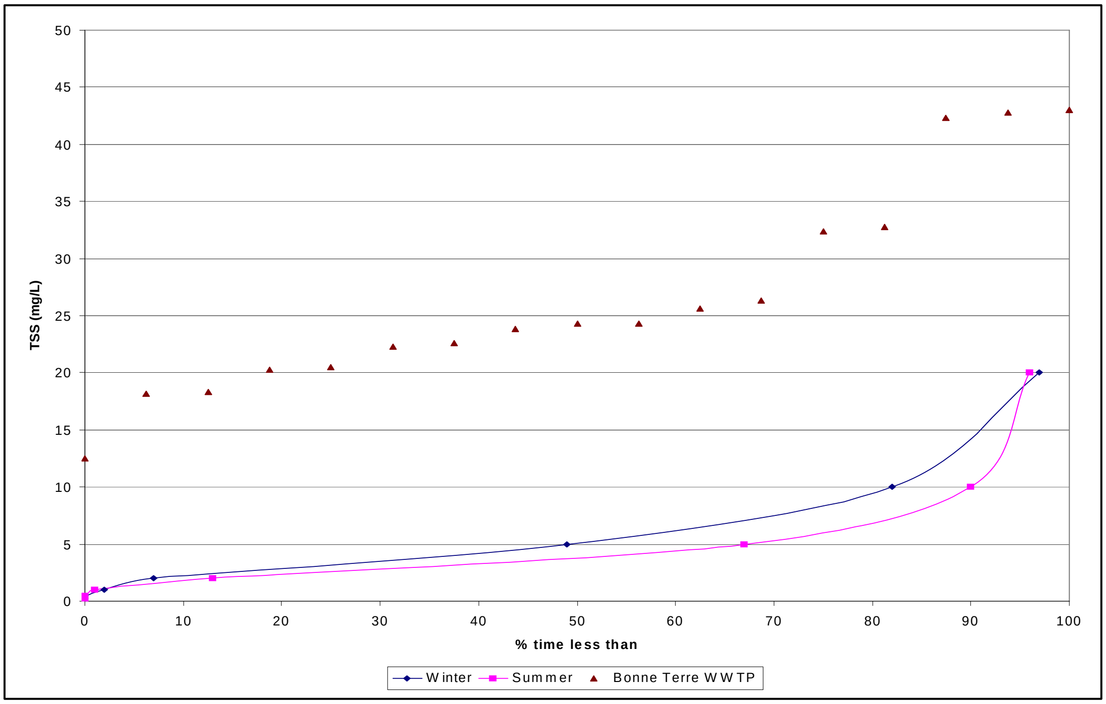


Figure 8: Comparison of average monthly TSS concentration in effluent from Bonne Terre WWTF and 16 other oxidation ditch systems.



Given that effluent limits for this facility need to be significantly reduced, an addition of tertiary treatment, such as filtration, to this system is recommended. The capability for reducing BOD and TSS in the effluent should be to meet proposed effluent limits at least 95 percent of the time. It has been suggested that an oxidation ditch with filtration should be able to meet effluent limits of 8 mg/L for BOD and TSS and 1.2 mg/L for NH_3-N (Neher, 2004).

10. Reasonable Assurances

The department has the authority to write and enforce NPDES permits. Inclusion of effluent limits for BOD, TSS, NH_3-N and other parameters, as necessary, in a State Operating Permit, and quarterly monitoring of the effluent reported to the department, should provide reasonable assurance that instream water quality standards will be met.

11. Public Participation

This water quality limited segment is included on the approved 2002 303(d) list for Missouri. The MDNR Water Protection Program developed this TMDL. The public notice period was from Nov. 19 to Dec. 19, 2004. Groups receiving the public notice announcement included the Missouri Clean Water Commission, Bonne Terre Northwest WWTF, the Water Quality Coordinating Committee, the TMDL Advisory Committee, Stream Team volunteers (11) in the watershed, appropriate legislators (3) and others that routinely receive the public notice of NPDES permits. All comments received and the department's response to those comments may be found in the Turkey Creek file.

12. Appendices And List Of Documents On File With The Department

Appendix A – Land use map for Turkey Creek watershed
Appendix B – Topographic map showing WWTF location and impaired segment
Appendix C – Turkey Creek Data and Statistical Summary

Supporting documents on file:
Bonne Terre Northwest WWTF - Permit No. MO-0100706
QUAL2E Input and Output
2002 Stream Survey by the department: Stream Survey Sampling Report, Bonne Terre WWTF and Turkey Creek, Bonne Terre, Missouri, St. Francois County.
Public Notice announcement
Turkey Creek Information Sheet
Public comment and department response

References

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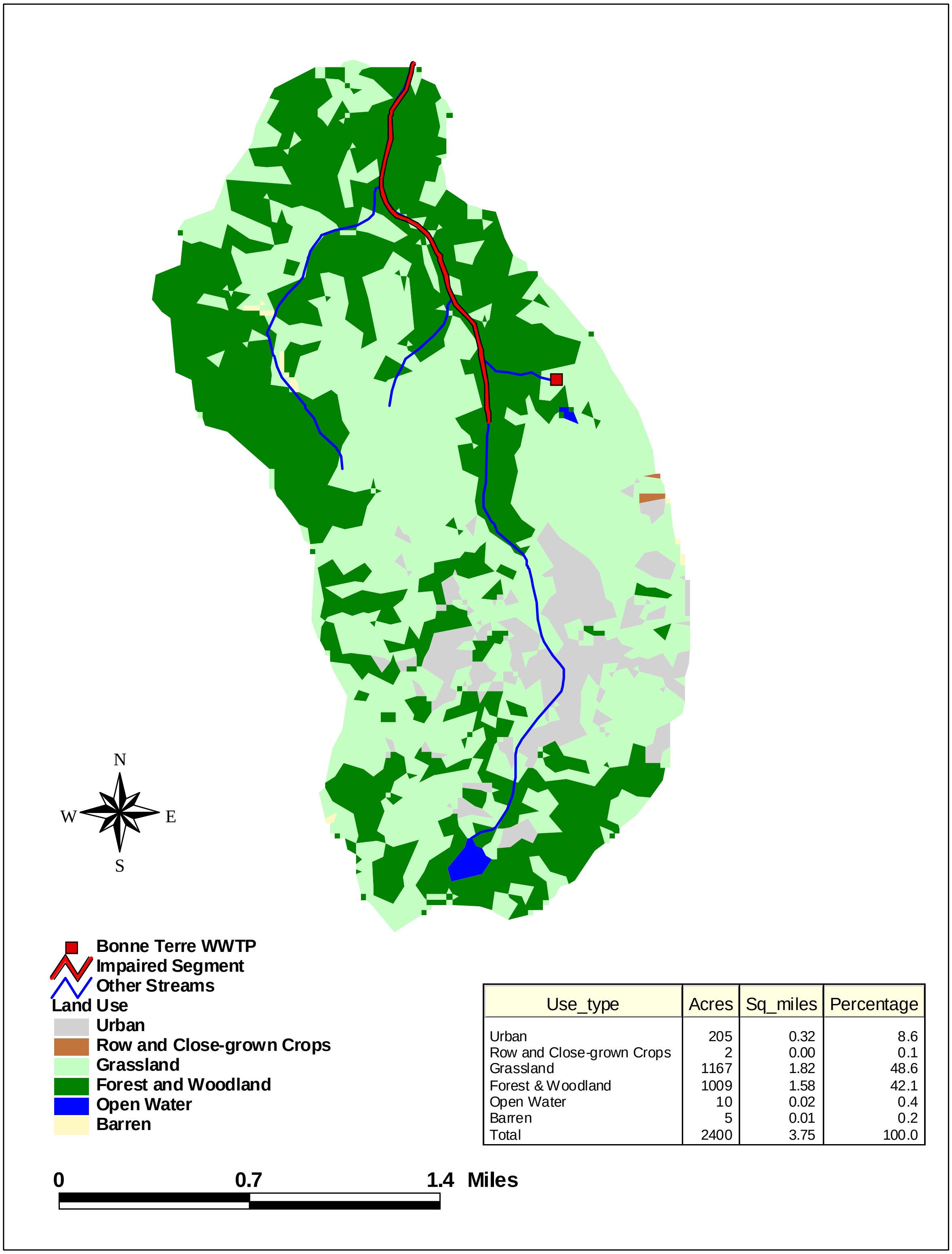
Neher, Leland. MDNR. 2004. Personal Communication.

US Environmental Protection Agency. Office of Water. September 1992. "Evaluation of Oxidation Ditches for Nutrient Removal". EPA 832-R-003.

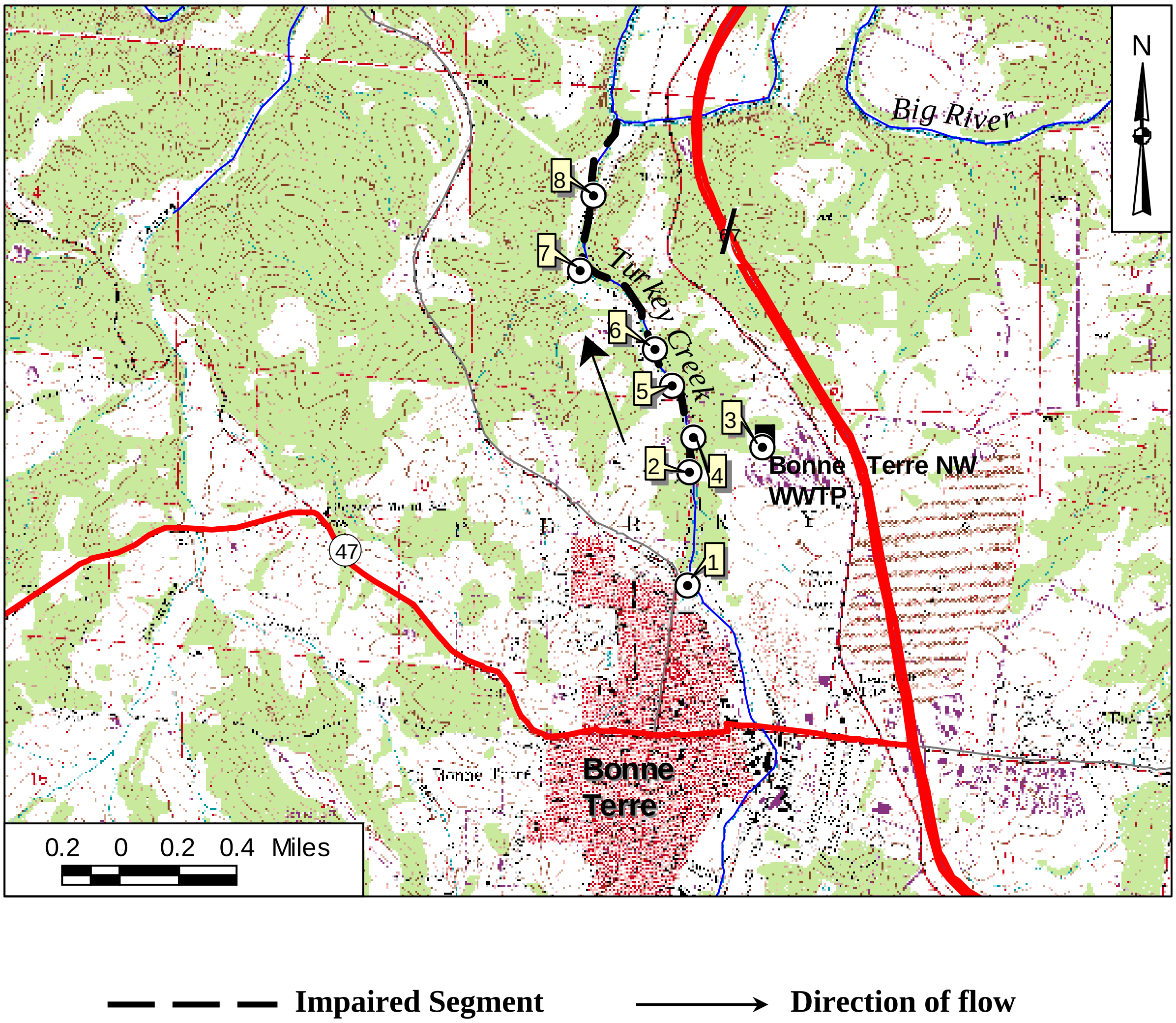
US Environmental Protection Agency. Office of Water. March 1991. "Technical Support Document for Water Quality-based Toxics Control". EPA 505/2-90-001.

Appendix A
Land use map for Turkey Creek watershed



Use_type	Acres	Sq_miles	Percentage
Urban	205	0.32	8.6
Row and Close-grown Crops	2	0.00	0.1
Grassland	1167	1.82	48.6
Forest & Woodland	1009	1.58	42.1
Open Water	10	0.02	0.4
Barren	5	0.01	0.2
Total	2400	3.75	100.0

Appendix B
Turkey Creek in St. Francois County, Missouri,
Showing the Impaired Segment and Sampling Sites



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Appendix C
Turkey Creek Data and Statistical Summary

Site	Site Name	Year	Mo	Day	Time	C	F	DO	KJN	NH3N	O-N	NO3N	TN	TP	VSS	CBOD
1	Turkey Creek 0.5 mi. US of WWTF trib	2002	7	23	515	23	73	3.7	0.31	0.025	0.28501	0.07	0.38	0.07	2.499	1.1
2	Turkey Creek 0.1 mi. US of WWTF trib	2002	7	23	540	24	75	3.5	4.79	1.58	3.21	0.41	5.2	6.41	14	4
4	Effluent tributary near mouth	2002	7	23	725	24	75	2.44	4.41	2.37	2.04	0.15	4.56	6.47	2.499	20
5	2nd tributary to Turkey Creek near mouth	2002	7	23	630	20	68	4.4	1.78	0.57	1.21	1	2.78	0.29	2.499	4
7	3rd tributary to Turkey Creek near mouth	2002	7	23	615	22	72	3	0.2	0.025	0.17501	0.02499	0.22	0.05	2.499	0.99
8	Turkey Creek 1.2 mi. DS of Bonne Terre WWTF	2002	7	23	555	23	73	4.9	2.35	0.41	1.94	1.45	3.8	4.52	2.499	2.5
1	Turkey Creek 0.5 mi. US of WWTF trib	2002	7	23	1305	26	79	9.2	0.34	0.025	0.31501	0.12	0.46	0.06	2.499	0.99
2	Turkey Creek 0.1 mi. US of WWTF trib	2002	7	23	1320	26	79	3.9	4.71	2.54	2.17	0.49	5.2	6.2	2.499	5
3	Bonne Terre WWTF outfall 001	2002	7	23	1245	27	81	6.27	6.84	0.27	6.57	0.36	7.2	5.55	34	10
5	2nd tributary to Turkey Creek near mouth	2002	7	23	1405	22	72	3.7	0.62	0.12	0.5	0.83	1.45	0.18	2.499	0.99
7	3rd tributary to Turkey Creek near mouth	2002	7	23	1355	24	75	4.6	0.21	0.025	0.18501	0.02499	0.23	0.06	6	0.99
8	Turkey Creek 1.2 mi. DS of Bonne Terre WWTF	2002	7	23	1335	25	77	5.6	1.64	0.26	1.38	1.16	1.8	4.1	2.499	0.99
2	Turkey Creek 0.1 mi. US of WWTF trib	2002	7	24	550	21	70	5.93	0.31	0.025	0.28501	0.1	0.41	0.06	2.499	0.99
3	Bonne Terre WWTF outfall 001	2002	7	24	615	25	77	4.79	11	0.025	10.975	0.02499	11	6.73	106	42
5	2nd tributary to Turkey Creek near mouth	2002	7	24	700	19	66	4.4	0.87	0.26	0.61	0.83	1.7	0.22	2.499	2
6	Turkey Cr. 0.5 mi. bl. Bonne Terre WWTF	2002	7	24	530	22	72	3.3	4.88	2.6	2.28	0.34	5.22	6.46	9	5
7	3rd tributary to Turkey Creek near mouth	2002	7	24	645	20	68	3.3	0.099	0.025	0.07401	0.02499	0.12	0.05	2.499	0.99
8	Turkey Creek 1.2 mi. DS of Bonne Terre WWTF	2002	7	24	512	21	70	4.6	2.01	0.4	1.61	1.6	3.61	4.42	7	3
2	Turkey Creek 0.1 mi. US of WWTF trib	2002	7	24	1415	27	81	9.6	0.22	0.025	0.19501	0.02499	0.24	0.06	2.499	0.99
3	Bonne Terre WWTF outfall 001	2002	7	24	1430	28	82	6.02	4.68	1.04	3.64	0.09	4.77	5.05	24	8
5	2nd tributary to Turkey Creek near mouth	2002	7	24	1345	21	70	4.4	0.6	0.29	0.31	0.8	1.4	0.19	5	0.99
6	Turkey Cr. 0.5 mi. bl. Bonne Terre WWTF	2002	7	24	1355	26	79	3.6	4.85	2.52	2.33	0.45	5.3	5.36	6	5
7	3rd tributary to Turkey Creek near mouth	2002	7	24	1330	23	73	4.62	0.26	0.025	0.23501	0.02499	0.28	0.06	2.499	0.99
8	Turkey Creek 1.2 mi. DS of Bonne Terre WWTF	2002	7	24	1300	23	73	6.2	1.53	0.22	1.31	1.41	2.95	4.03	2.499	0.99
1	Turkey Creek 0.5 mi. US of WWTF trib	2002	8	28	700	16	61	9.4	0.099	0.02499	0.07401	0.36	0.46	0.025	2.499	0.99
2	Turkey Creek 0.1 mi. US of WWTF trib	2002	8	28	630	18	64	8.7	0.43	0.02499	0.40501	0.54	0.97	1.37	2.499	0.99
3	Bonne Terre WWTF outfall 001	2002	8	28	725	25	77	6.73	1.85	0.16	1.69	0.89	2.74	5.24	2.499	0.99
5	2nd tributary to Turkey Creek near mouth	2002	8	28	700	17	63	6	0.53	0.11	0.42	1.36	1.89	0.32	2.499	0.99
7	3rd tributary to Turkey Creek near mouth	2002	8	28	715	19	66	5.3	0.26	0.02499	0.23501	0.02499	0.28	0.025	2.499	0.99
8	Turkey Creek 1.2 mi. DS of Bonne Terre WWTF	2002	8	28	720	18	64	8.5	0.37	0.02499	0.34501	0.53	0.9	1.2	2.499	0.99
1	Turkey Creek 0.5 mi. US of WWTF trib	2002	8	28	1350	20	68	10.4	0.099	0.02499	0.07401	0.33	0.43	0.025	2.499	0.7
2	Turkey Creek 0.1 mi. US of WWTF trib	2002	8	28	1330	23	73	8.4	1.09	0.1	0.99	2.35	3.44	3.1	2.499	0.99
3	Bonne Terre WWTF outfall 001	2002	8	28	1425	26	79	6.98	2.86	1.18	1.68	3.01	5.87	4.72	2.499	0.99
5	2nd tributary to Turkey Creek near mouth	2002	8	28	1345	22	72	8.9	0.58	0.02499	0.55501	0.84	1.42	1.64	2.499	0.99
7	3rd tributary to Turkey Creek near mouth	2002	8	28	1330	20	68	5.8	0.39	0.07	0.32	1.31	1.7	0.29	2.499	0.99
8	Turkey Creek 1.2 mi. DS of Bonne Terre WWTF	2002	8	28	1340	24	75	7	0.41	0.02499	0.38501	0.02499	0.43	0.025	2.499	1.4
2	Turkey Creek 0.1 mi. US of WWTF trib	2002	8	29	630	18	64	7.5	0.099	0.02499	0.07401	0.22	0.32	0.05	2.499	0.99

3	Bonne Terre WWTF outfall 001	2002	8	29	750	25	77	6.71	1.68	0.15	1.53	1.66	3.34	5.16	2.499	0.99
5	2nd tributary to Turkey Creek near mouth	2002	8	29	730	17	63	6.13	2.07	0.53	1.54	1.14	3.21	0.5	7	6.6
6	Turkey Cr. 0.5 mi. bl. Bonne Terre WWTF	2002	8	29	640	20	68	7.3	0.92	0.02499	0.89501	1	1.92	3.38	2.499	0.99
7	3rd tributary to Turkey Creek near mouth	2002	8	29	710	19	66	4.45	0.099	0.02499	0.07401	0.02499	0.12	0.08	2.499	0.99
8	Turkey Creek 1.2 mi. DS of Bonne Terre WWTF	2002	8	29	655	19	66	7.5	0.8	0.02499	0.77501	1.25	2.05	2.93	2.499	0.99
2	Turkey Creek 0.1 mi. US of WWTF trib	2002	8	29	1415	23	73	11.5	0.22	0.02499	0.19501	0.16	0.38	0.05	6	0.99
3	Bonne Terre WWTF outfall 001	2002	8	29	1300	25	77	7.22	2.03	0.39	1.64	4.92	6.95	5.32	6	0.99
5	2nd tributary to Turkey Creek near mouth	2002	8	29	1345	19	66	6.51	0.48	0.07	0.41	1.15	1.63	0.3	6	0.99
6	Turkey Cr. 0.5 mi. bl. Bonne Terre WWTF	2002	8	29	1400	24	75	7.9	1.44	0.02499	1.41501	4.11	5.55	4.35	5	0.99
7	3rd tributary to Turkey Creek near mouth	2002	8	29	1330	22	72	5.5	0.099	0.02499	0.07401	0.02499	0.12	0.025	5	0.99
8	Turkey Creek 1.2 mi. DS of Bonne Terre WWTF	2002	8	29	1315	21	70	9.2	0.89	0.02499	0.86501	1.1	2	3.07	5	0.99

C=temperature in degrees Celsius, F=temprature in degrees Fahrenheit, DO=Dissolved Oxygen, KJN= Kjeldahl Nitrogen, NH3N=Ammonia as Nitrogen, O-N=Organic Nitrogen, NO3N =Nitrate as Nitrogen, TN=Total Nitrogen**,** TP=Total Phosphorus, VSS=Volatile Suspended Solids, CBOD=Carbonaceous Biochemical Oxygen Demand

Statistical Summaries for Flow, Total Nitrogen and Total Phosphorus at Four Sites to Supplement the Geometric Mean Data (see page 10)

		Flow (ft^3/s)	Total Nitrogen (mg/L)	Total Phosphorus (mg/L)
Upstream of effluent tributary	Minimum	0.004	0.24	0.05
	25th percentile	1.164	0.365	0.0575
	Median	1.76	0.69	0.715
	75th percentile	1.8275	3.88	3.875
	Maximum	2.1	5.2	6.41
2nd tributary	Minimum	0.004	1.4	0.18
	25th percentile		1.443	0.2125
	Median	(0.22)	1.665	0.295
	75th percentile		2.113	0.365
	Maximum	0.04	3.21	1.64
3rd tributary	Minimum	0.004	0.12	0.025
	25th percentile		0.124	0.044
	Median	(0.042)	0.225	0.055
	75th percentile		0.28	0.065
	Maximum	0.08	1.7	0.29
Outfall #1	Minimum	0.1427	2.74	4.72
	25th percentile	0.237	4.195	5.1325
	Median	0.478	5.32	5.28
	75th percentile	0.562	7.013	5.7725
	Maximum	0.69	11.02	6.73